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Distributive cycles and wage inequality: a Kaleckian Goodwin-inspired model

1. Motivation

The rise in wage inequality since the 1980s- particularly in the United States but also in several other developed countries- has been widely reported in many studies (Piketty and Saez, 2003; Carvalho and Rezai, 2015; Tavani and Vasudevan, 2014; Lavoie, 2009; EPI, 2011; Mohun, 2014; Galbraith, 2011, 2012; Piketty, 2014; Saez and Veall, 2005; Mohun, 2006; Duménil and Levy, 2010, 2004; Bakija et al., 2012).

Amongst the main reasons for this phenomenon, the literature highlights institutional and economic policy aspects that have redistributed income in favor of high-income segments of the business bureaucracy (such as tax and financial liberalization laws) (Duménil and Levy, 2004) rather than factors linked to the increasing productivity of these groups, such as technological changes (Alvaredo et al., 2013; Michel and Bivens, 2021; Bivens and Michel, 2013). Other authors have interpreted the increasing wage inequality as reflecting slow-moving secular trends and, in particular, the effects of technical change that has generally favored relatively high-skill workers (Katz and Murphy, 1992; Murphy and Welch, 1992).

While this literature has focused primarily on long-term trends (Acemoglu, 2002; Autor and Katz, 1999; Autor et al., 2008; Katz and Murphy, 1992; Murphy and Welch, 1992) and the dynamics of inequality at the very top (Piketty and Saez, 2003), it has overlooked the cyclical pattern of inequality. There is evidence, however, that the inequality in the left tail (middle-bottom) widens sharply during recessions and tends to decrease gradually during the subsequent recoveries, while inequality between the top and the bottom of the wage distribution increases steadily (Heathcote et al., 2020; Guvenen et al., 2017).

Heathcote et al. (2020) present that there is a solid cyclical component to the dynamic of earnings inequality at the bottom. In a study for the US, the authors contend that the nature of the earnings inequality increases at the top and the bottom is different. While the earnings ratio 90/50 increased steadily until 2010, it does not exhibit any particular cyclical pattern. Moreover, it is determined by the differential growth in real wages at the top compared to the middle. On the other hand, the inequality at the bottom (ratio 50/20) rises sharply in each recession, and it is determined by both a decrease in employment and lower wages. There is also evidence that this rise in inequality is persistent over time during the recovery. Similar results have been reported by other authors (Bonhomme and Hospido (2012) for Spain; Alessandrini et al. (2016) for the US; Bowlus et al. (2021) for Canada; Guvenen et al. (2017) for the US).

These findings are consistent with the empirical literature that estimates the effect of the business cycle on income inequality. It typically finds that the bottom segments of the distributional pyramid suffer more from a recession, given that their income is

more subject to changes in the unemployment rate - that is, inequality is countercyclical (Kuznets, 1953; Parker, 1998; Blank and Blinder, 1986; Blinder and Esaki, 1978; Dimelis and Livada, 1999; Bishop et al., 2020; Maestri and Roventini, 2012; Hoover et al., 2009; Geiger et al., 2020; Krueger et al., 2010; Atem and Jones, 2014)[1].

In particular, there is growing evidence of the disproportionate impacts of recessions on low-skilled workers, since they are more vulnerable to business cycle movements (Hoynes et al., 2012; Clark and Summers, 1981; Hoynes, 1999; Hershbein and Kahn, 2018; Forsythe, 2019; Kydland, 1984). Morin (2019), Mueller (2017), and Solon et al. (1994) report that, typically, the employed worker during recessions is more skilled.

Bernstein and Bentele (2019) state, in a study for the U.S, that the real earnings of workers at the bottom of the distributive pyramid are quite responsive to the unemployment rate: the increased bargaining power of these workers when the unemployment rate declines is important for the real growth of their income. This clear relationship, however, is not observed for workers at the top of the income distribution (Bernstein, 2016a; 2016b). Moreover, empirical evidence of the Goodwin cycle reported in the literature suggests the importance of workers' bargaining mechanisms when the economy grows (Barbosa Filho and Taylor, 2006; Mendieta-Munhoz et al., 2020).

The evidence of countercyclical wage inequality has not been addressed often in theoretical models. Although there is a growing literature about Kaleckian models that incorporate personal distribution (Lavoie 1996, 2009; Lavoie and Nah, 2020; Palley, 2016; Palley, 2017; Palley, 2014a, Palley, 2014b; Tavani and Vasudevan, 2014; Dutt, 2016), these studies have been considering the wage inequality between the top and the bottom of the wage distribution by building models with two types of workers: workers and the managerial class. Using this approach, they neglect the effect of the cycle/aggregate demand on wage inequality.

The purpose of our model is to fill this gap. The model includes three classes in a Kaleckian-Goodwinian approach – capitalists and two types of workers. We analyze the cyclical dynamics of wage inequality, that is, the effect of aggregate demand on the wage inequality between the middle (higher skilled workers- e.g., industrial sector) and the bottom (e.g., service sector). In the case of workers at the bottom of the wage pyramid, the wage growth rate is more sensitive to employment growth (through the wage bargaining mechanism in the labor market in a Goodwinian framework) (Cassetti, 2003). Besides the traditional result that wage inequality can have a negative impact on aggregate demand, we found that policies aimed at reducing wage inequality are essential to avoid a stable equilibrium with low-capacity utilization levels and high wage inequality.

[1] An exception is the study by Camacho and Palmieri (2019) for a panel of 43 countries, which finds that inequality is procyclical in most cases - especially in emerging countries. However, many of the results lack statistical significance.

The rest of this paper is structured as follows. Section 2 provides a review on the literature on Kaleckian models and personal income distribution. Section 3 presents the model and its extensions. Finally, Section 4 concludes.

2. Related Literature

A few years ago, personal income distribution was barely explored in this literature (Tavani and Vasudevan, 2014). More recently, this approach has been developed in Kaleckian-inspired models (Lavoie, 2009; Lavoie and Nah, 2020; Palley, 2016, 2014a, 2014b, 2017; Tavani and Vasudevan, 2014; Dutt, 2016; Carvalho and Rezai, 2015; Prante, 2018; Hein and Prante, 2018; Sasaki et al., 2013; Sonoda and Sasaki, 2019), motivated by the rise in inequality in rich countries since the 1980s.

Wage inequality in neo-Kaleckian models has been addressed in two ways[2]: i) introduction of a third class - managerial workers - in addition to workers and capitalists (Lavoie, 1996, 2009; Lavoie and Nah, 2020; Palley, 2016, 2014a, 2014b, 2017; Tavani and Vasudevan, 2014; Dutt, 2016); ii) endogenization of the worker's propensity to save (Carvalho and Rezai, 2015; Prante, 2018; Hein and Prante, 2018).

These models commonly find that wage income concentration has contractionary impacts by redistributing income from workers at the bottom of the distributional pyramid, whose propensity to consume is higher, to richer workers, who have a higher propensity to save. Such redistribution depresses household consumption and negatively impacts the rate of capacity utilization (Lavoie and Nah, 2020; Palley, 2016, 2017, 2014a, 2014b; Carvalho and Rezai, 2015; Prante, 2018; Prante and Hein, 2018). Other models highlight that increasing wage inequality generates destabilizing fluctuations in the economy (Sasaki et al., 2013; Sonoda and Sasaki, 2019).

A general result of these models is that wage inequality and personal income distribution affect how functional income distribution (between wages and profits) influences economic growth. In particular, a rise in wage inequality causes a hike in the average propensity to save on labor income. It weakens the positive effect of income redistribution in favor of wages. Thus, a wage-led demand regime is more likely when wage inequality is low (Carvalho and Rezai, 2015; Oyvat et al., 2020; Palley, 2016, 2014b, Lavoie and Nah, 2020).

Table 1 below describes each model in terms of interactions between demand and functional/personal income distribution. The arrows indicate the direction of causality that the model addresses.

[2] Dutt (1992) does not make explicit a third class in the model, but was one of the first models to address the issue, assuming the existence of a lower productivity sector.

Table 1 - Wage Inequality and Kaleckian Models - Part 1

Model	Functional Distribution→ Demand	Demand → Functional Distribution	Personal Distribution → Demand	Demand → Personal Distribution
Lavoie (1996), Lavoie (2009). Three classes: firms, managers, and workers.	Stagnation: an increment in wage inequality redistributes income from profits to wages and has an expansionary impact on the rate of capacity utilization. Expansion: a rise in wage inequality redistributes income from workers to managers and firms (profits) via higher prices. It implies a negative impact on the rate of capacity utilization.		Stagnation: an increment in wage inequality redistributes income from firms to the managerial class, which offsets the reduced worker's income share. Expansion: an increase wage inequality implies higher price levels and lower demand by reducing the worker's income share.	
Lavoie and Nah (2020). Three classes: firms, managers, and workers.	A rise in wage inequality redistributes income from a firm's retained earnings to managers. The positive impact on the degree of capacity utilization is more likely if s_f (saved fraction of profits) is high and s_h (managerial class' propensity to save) is low. A higher wage inequality diminishes the "wage-ledness" of the economy in the long run.		A rise in wage inequality redistributes income from workers to managers. A negative impact on the capacity utilization rate is more likely if s_f is low and s_h is high. In the long run, a greater wage inequality leads to decreased economic growth.	

Table 1 - Wage Inequality and Kaleckian Models - Part 2

Model	Functional distribution → Demand	Demand → Functional distribution	Personal distribution → Demand	Demand→ Personal distribution
Carvalho and Rezai (2015). Two classes (capitalists and workers)	Wage inequality diminishes the multiplier effect. Wage-led demand is less likely when there is high wage inequality.		A smaller wage inequality always leads to a positive impact on the rate of capacity utilization.	
Prante (2018)/ Hein and Prante (2018). Two classes (capitalists and workers)	A greater inequality in terms of functional income distribution leads to a negative impact on the rate of capacity utilization if the economy is wage-led and, also, if: i) there are not any conspicuous consumption effects or, if there are such effects, ii) personal redistribution to higher wages is more pronounced than redistribution to profits.		Wage inequality is a positive function of functional inequality. A more extensive wage inequality implies a positive effect on the rate of capacity utilization (inequality-led) if there is a conspicuous consumption impact. Otherwise, there is the Carvalho and Rezai's (2015) result (adverse effect on the rate of capacity utilization).	
Oyvat el al (2020). Three classes	Profit-led demand regime when wage inequality is elevated is more probable.			
Palley (2016). Two classes (capitalist-managers and workers).	Wage-led demand is less likely when there is an increase in wage inequality. Profit-led is less probable when there is larger inequality in terms of the capital income distribution.		Smaller inequalities (wage and capital) have positive impacts on the degree of capacity utilization/ on the economic growth.	

Table 1 - Wage Inequality and Kaleckian Models - Part 3

Model	Functional distribution → Demand	Demand → Functional distribution	Personal distribution → Demand	Demand→ Personal distribution
Palley (2017). Two classes (capitalist-managers and workers).	Wage-led demand is less likely when there is larger wage inequality. Profit-led is less probable when there is greater inequality in terms of the capital income distribution.	Profit share is endogenous. If the rate of capacity utilization is low, the distributive curve indicates a wage squeeze. If the rate of capacity utilization is higher, there is a profit squeeze due to the strengthening of workers' bargaining power.	Lower wage and capital income inequalities positively affect the capacity utilization rate.	
Palley (2014a). Two classes (capitalist-managers and workers).	Profit or wage-led (wage inequality does not affect the demand regime).		A reduced wage inequality (due to an increase in the employment rate, for example) leads to a rise in the rate of capacity utilization.	Personal income distribution depends on the employment rate (a state variable adjusted in the long run) and on an exogenous parameter that captures the bargaining power of workers.

Table 1 - Wage Inequality and Kaleckian Models - Part 4

Model	Functional distribution → Demand	Demand → Functional distribution	Personal distribution → Demand	Demand→ Personal distribution
Palley (2014b). Three classes (capitalists, managers, and workers).	A diminished wage inequality raises the chance that the economy will exhibit a wage-led demand regime.		More significant wage and capital inequalities have a negative impact on demand.	More pronounced wage inequality is caused by lower employment rates (a state variable adjusted in the long run) and by exogenous conditions linked to the workers' bargaining power.
Tavani and Vasudevan (2014). Three classes (capitalists, managers, and workers).	Regime 1: higher functional distribution inequality has a negative impact on the rate of capacity utilization (wage-led). Regime 2: the opposite effect (profit-led).		Regime 1: an upsurge in wage inequality causes a redistribution from profits to wages. Since the economy is wage-led, the impact on the rate of capacity utilization is positive. Regime 2: greater personal inequality negatively impacts the capacity utilization rate (profit-led case).	In the long run, wage inequality depends on demand and its persistence. There is a stable equilibrium only in regime 1 (if the wage squeeze is not so high). Larger wage inequality reduces workers' income share and stimulates economic growth (inequality-led regime).

Table 1 - Wage Inequality and Kaleckian Models - Part 5

Model	Functional distribution → Demand	Demand → Functional distribution	Personal distribution → Demand	Demand→ Personal distribution
Dutt (2016). Two classes (capitalists, managers; and workers).	Higher manager wages imply redistribution from firms to managers. It positively impacts the rate of capacity utilization (although the total impact is ambiguous).		A greater wage inequality has an ambiguous impact (in the short and long run). It positively impacts the rate of capacity utilization (redistribution from profits to wages) but also has a negative effect (redistribution from workers to managers). A more considerable inequality in terms of capital income has a negative impact on the rate of capacity utilization.	
Sasaki et al (2013). Three classes: regular and non-regular workers; and capitalists.	Wage and profit-led (usual sense).		An increment in wage inequality creates instability in the long-run equilibrium (profit-led case).	
Sonoda and Sasaki (2019). Three classes: regular and non-regular workers; and capitalists.	Wage and profit-led (usual sense).		Wage conflict between the two types of workers produces instability in the long-run equilibrium (wage-led case).	

Although this literature has dealt extensively with the effect of wage inequality on aggregate demand (as shown in Table 1), it has looked much less at the opposite causality: the effect of aggregate demand on the interpersonal distribution of income. The empirical literature reinforces the importance of this channel in the relationship between the business cycle and inequality, commented earlier (Kuznets, 1953; Parker, 1998; Blank and Blinder, 1986; Blinder and Esaki, 1978; Dimelis and Livada, 1999; Bishop et al., 2020; Maestri and Roventini, 2012; Hoover et al., 2009; Geiger et al., 2020; Atems and Jones, 2014; Bernstein and Bentele, 2019).

The effect of demand on the functional distribution of income, on the other hand, is widely addressed in the literature that has developed the dynamic relationship between income distribution and the rate of capacity utilization. It approaches the possibility that income distribution behaves endogenously in a theoretical framework that deals with distributional conflicts between workers and capitalists (Flaschel and Krolzig, 2006; Tavani et al., 2011; Rezai, 2012). These models take inspiration from Goodwin (1967) (extension in Taylor, 2004), in which the higher profit share in income stimulates investment and increases the employment rate and the rate of capacity utilization (profit-led economy), as well as the demand for labor. This process strengthens workers' bargaining power and expands the wage share in income (Rowthorn, 1977). The profit squeeze, in turn, discourages investment and employment, reversing the expansionary wage cycle. This dynamic restores profitability and compresses the wage share in income, and the economy returns to the initial situation.

The Goodwin model assumes that savings determine investment (there are no demand constraints) (Stockhammer, 2017; Stockhammer and Michell, 2016). The extension by Taylor (2004) builds a Kaleckian demand-led model inspired by Goodwin (1967) (Stockhammer, 2017). In his model, if real wages respond more to the rate of capacity utilization than productivity does, there is a profit squeeze scenario. There is a redistribution in favor of workers: the wage share in income expands while the rate of capacity utilization increases. On the other hand, if the response of labor productivity to demand shocks is more significant, the economy experiences a forced saving process (or wage squeeze) with income redistribution to capitalists.

Theoretical contributions to the Kaleckian literature studying the Goodwin cycle have been made by Tavani et al. (2011), building on Flaschel and Krolzig (2006), and by Rezai (2012), in addition to that by Taylor (2004). Such authors start from "wage-price spiral" equations, which make explicit the distributional conflict between workers and capitalists. In these models, the distributive curve presents a profit squeeze behavior: i) if the sensitivity of nominal wages variation to aggregate demand, which depends on the bargaining power of workers in the labor market, exceeds the sensitivity of prices variation to demand; ii) if real wages respond more to the capacity utilization rate than productivity

does.

Tavani et al. (2011), for example, make the nominal wages variation endogenous. It becomes dependent on the rate of capacity utilization. When the employment rate is more pronounced, there is an increase in workers' bargaining power. Consequently, wage inflation is more intense than price inflation (profit squeeze). As a result, the distributive curve depends on the business cycle. In particular, the profit squeeze occurs when aggregate demand heats up. The model theorizes, in this sense, the econometric results found by Nikiforos and Foley (2012)[3].

In the Goodwin-inspired Kaleckian empirical literature, which endogenizes income distribution, there is ample evidence about the existence of Goodwin cycles for the United States economy after the Second War - that is, the combination of profit-led and profit squeeze regimes (Taylor, 2004; Barbosa Filho and Taylor, 2006; Diallo et al., 2011; Kiefer and Rada, 2015; Proano et al., 2006; Carvalho and Rezai, 2015; Barrales-Ruiz and Von Arnin, 2020; Basu and Gautham, 2019; Barrales-Ruiz et al., 2021; Rolim, 2019; Skott and Zipperer, 2012; Mendieta-Munoz et al., 2020; Vechsuruck, 2017; Basu et al., 2013). Similar results appear in studies by Chen and Flaschel (2006) and Flaschel and Krolzig (2006), who estimate that real wages are procyclical. Some authors have pointed out evidence of nonlinearities (Nikiforos and Foley, 2012; Tavani et al., 2011; Cauvel, 2019; Carvalho and Rezai, 2015). Other authors are more skeptical of Goodwin cycles (Veneziani and Mohun, 2006; Harvie, 2000; Stockhammer and Stehrer, 2011; Stockhammer, 2017; Onaran et al., 2011; Onaran and Galanis, 2012; Blecker et al., 2020; Setterfield, 2021). Finally, some authors highlight the weakening of distributional cycles in the US economy during the period based on so-called neoliberal policies (Setterfield, 2021; Mendieta-Munoz et al., 2020).

To sum up, according to the Kaleckian Goodwin-inspired literature, the profit squeeze effect (the wage share in income expands while the rate of capacity utilization increases) occurs when the economy is growing, and the strengthening of worker's bargaining power is able to offset the response of prices to demand and the pro-cyclical effect of labor productivity. In this context, inflation does not necessarily respond to higher economic activity. Greater bargaining power of workers due to growing labor demand, for example, could decrease a firm's markups and the inflation rate (Kalecki, 1971; Lavoie, 1992; Rowthorn, 1977).

Empirical estimations carried out by Barbosa-Filho (2014) and by Taylor and Barbosa-Filho (2021) for the US economy conclude that income distribution - the wage share - is the leading domestic factor affecting inflation (rather than the capacity utilization rate).

[3] Rezai (2012) extends Tavani et al.'s (2011) model and considers the endogeneity of labor productivity but does not take into account possible nonlinearities. The profit squeeze condition is that, in addition to nominal wages being more flexible than prices, such an effect via strengthening bargaining power should outweigh the impact of the Kaldor Verdoorn effect on labor productivity.

This evidence is consistent with the idea that wage repression has allowed the emergence of a "flat" Phillips curve in the U.S. economy (Setterfield, 2006; Taylor and Barbosa-Filho, 2021; Bernstein and Bentele, 2019; Barbosa-Filho, 2014; Stansbury and Summers, 2020; Flaschel et al., 2021). According to this literature, wage repression has appeased the intensity of the distributional conflict and allowed low inflation and unemployment rates to be compatible over the last twenty years since prices respond mainly to the wage share.

At the same time, Bernstein and Bentele (2019), in a study of the US economy, have observed that the real earnings of workers at the bottom of the distributive pyramid are quite responsive to the unemployment rate. This clear relationship, however, is not observed for workers at the top. Based on this evidence, Bernstein and Bentele (2019) and Bernstein (2016a) suggest that full employment has an equalizing impact on the economy, boosting the real earnings of poorer workers.

Empirical evidence of the Goodwin cycle reported in the literature suggests the importance of worker's bargaining mechanism when the economy is growing (Taylor, 2004; Barbosa Filho and Taylor, 2006; Diallo et al., 2011; Kiefer and Rada, 2015; Proano et al., 2006; Carvalho and Rezai, 2015; Barrales-Ruiz and Von Arnin, 2020; Basu and Gautham, 2019; Barrales-Ruiz et al., 2021; Rolim, 2019; Skott and Zipperer, 2011; Mendieta-Munoz et al., 2020; Vechsuruck, 2017; Basu et al., 2013). Such results are also consistent with the evidence that inequality is countercyclical and responds positively when the unemployment rate increases (Kuznets, 1953; Parker, 1998; Blank and Blinder, 1986; Blinder and Esaki, 1978; Dimelis and Livada, 1999; Bishop et al., 2020; Maestri and Roventini, 2012; Hoover et al., 2009; Geiger et al., 2020; Atem and Jones, 2014; Morin, 2019; Bernstein and Bentele, 2019).

This model aims to analyze the causality side "aggregate demand $\rightarrow$ wage distribution", in addition to the causality typically addressed by the literature (wage inequality $\rightarrow$ aggregate demand). In particular, the effect of aggregate demand on the personal income distribution through the mechanism of strengthening workers' bargaining power will be assessed. The model aims to answer the following questions: under what conditions does an economic expansion generate a decrease in wage inequality? What is the effect of wage inequality on demand?

The Kaleckian theoretical literature, as stated earlier, usually analyzes the impact of personal income distribution on aggregate demand. The Goodwin-inspired literature theorizes the opposite effect - of demand on the (functional) income distribution. Typically, this literature analyzes the functional distributional curve and investigates the conditions for a profit squeeze (Taylor, 2004). Conversely, it lacks a model incorporating wage distribution in a bi-causality relationship with aggregate demand. In particular, the model in the dissertation investigates the conditions for expansionary demand shocks to reduce wage inequality.

3. Model

Classes and income distribution

Inspired by Tavani and Vasudevan (2014) and Palley (2014b), the model has three classes: bottom workers (workers from the bottom of the distributive pyramid, less skilled - indexed by W); middle workers (who are from the middle of the distributive pyramid. They are more skilled and earn higher wages - indexed by M); capitalists (C). The production function is inspired by Tavani and Vasudevan (2014):

$$Y = min[\kappa K, aL_W, bL_M] \tag{1}$$

Where L_W: number of bottom workers employed; L_M: number of middle workers employed; a and b are their respective labor productivity; K is the capital and κ, its productivity.

The wage share ψ:

$$\psi = \psi_W + \psi_M = \frac{W_W L_W}{Y} + \frac{W_M L_M}{Y} \tag{2}$$

The functional income distribution incorporates the personal distribution among bottom workers and middle workers. The profit share is: $1 - \psi_W - \psi_M$. Bottom and middle workers "split" the wage bill. The wages W_W and W_M are expressed in real terms. We suppose the supply of labor is elastic for both types of workers.

We consider η>1 the wage premium obtained by middle workers. η is a wage inequality measure (Tavani and Vasudevan, 2014).

$$W_M = \eta W_W \tag{3}$$

The number of "middle workers" is a portion of the number of "bottom workers":

$$L_M = \xi L_W \tag{4}$$

So, in terms of wage share in income:

$$\psi_M = \xi \eta \psi_W \tag{5}$$

Structure

As seen in Section 1, our model aims to build a structure in which we can analyze how the wage inequality between the middle and the bottom of the wage pyramid responds to the economic cycle, given our empirical motivation. As we investigate the economic cycle,

our model is built for the short-run (we adopt the assumption of constant productivity - we will provide an extension of the model, in which we vary labor productivity).

The bottom worker's saving function - normalized by the capital stock - is:

$$S_W = s_W u \psi_W \tag{6}$$

The middle worker's saving function - normalized by the capital stock:

$$S_M = s_M u[\eta \xi \psi_W] \tag{7}$$

The capitalists' savings function is given by:

$$S_C = s_C u(1 - \psi_W - \psi_M) \tag{8}$$

Where s_W is the propensity to save of bottom workers, s_M is the propensity to save of middle workers and $s_C = 1$ is the propensity to save of capitalists. We consider the usual Kaleckian-Kaldorian assumption that $s_W < s_M < 1$.

The investment function normalized by the capital stock is a Kalecki-Steindl type. It depends on the rate of capacity utilization u and the profit rate r (γ_1, γ_2>0) - in addition to the autonomous investment γ_o, which reflects sales expectations by firms (Lavoie, 2014):

$$I = \gamma_o + \gamma_1 u + \gamma_2 r \tag{9}$$

Where r is the profit rate given by $r = \pi u$.

The effective demand adjustment is given by the equation:

$$\hat{u} = \mu(I - S) \tag{10}$$

Following the Goodwin's cycle theoretical literature (Taylor, 2004; Tavani et al., 2011; Rezai, 2012), we have two dynamic equations: effective demand and income distribution (wage inequality, in our case).

Our measure of wage inequality $\eta\xi$ is broader than only η: we also consider employment since the empirical literature shows that wage inequality during recessions increases not just due to the differential growth in real wages but also because there is vast evidence about the impact of the business cycle on employment (mainly for the bottom workers) (for example, Heathcote et al., 2020; Morin, 2019; Hoynes et al., 2012; Hoover et al., 2009).

$$\eta\xi = \frac{W_M L_M}{W_W L_W} \tag{11}$$

In terms of growth rate:

$$\hat{\eta\xi} = \hat{W_M} + \hat{L_M} - \hat{W_W} - \hat{L_W} \tag{12}$$

The bottom workers' real wage growth rate is given by:

$$\hat{W_W} = \Omega_0(\psi_W^{target} - \psi_W) + \sigma_1\hat{a} \tag{13}$$

Sonada and Sasaki (2019) construct different equations for two types of workers, considering that $\hat{W_W}$ responds positively to the degree of capacity utilization (bargaining power mechanism). We follow such authors, inspired by the empirical literature on Goodwin cycles, which emphasizes the importance of a growing economy to boost workers' bargaining power and income share (Taylor, 2004; Barbosa Filho and Taylor, 2006; Barrales-Ruiz and Von. Arnin, 2020; among others - See Section 2). We also take inspiration from the literature that finds that income inequality is countercyclical: in particular, workers from the bottom of the distributive pyramid are more vulnerable to changes in the unemployment rate (Geiger et al., 2020; Atem and Jones, 2014; Hoover et al., 2009; among others - See Section 1). Their wages are, therefore, more subject to the business cycle's movements. Finally, to express the bargaining power idea, many authors make the growth of wages depend on the employment rate (Skott, 1989; Dutt, 1992; Lavoie, 1992; Cassetti, 2002).

The wage growth equation is inspired by Palley (1992), Tavani, Flaschel and Taylor (2011), Taylor (2004), and Rezai (2012). Nevertheless, in our case, the bottom worker's target is endogenous and depends positively on e_W, the bottom workers' employment rate (λ_1>0), motivated by the bargaining power empirical evidence:

$$\psi_W^{target} = \lambda_1 e_W \tag{14}$$

We add that Ω_0 also depends on u. It means that the wage growth response to the employment rate is nonlinear: it is stronger when u is high and weaker otherwise, as Tavani et al. (2011) show empirically for the US[4]. Also, some studies (Chen and Flaschel (2006); Flaschel and Krolzig (2006)) estimate that real wages are procyclical. It is worth noting that Tavani et al. (2011) consider this nonlinearity in the functional distributive curve. The contribution of this essay is considering the personal income distribution in addition to the functional.

[4] According to Tavani et al. (2011) (p.526), "A standard Keynesian economic intuition behind the behavior of the curve will focus on the bargaining power of labor supply. For high levels of unemployment, the workers' bargaining power is small: they (or the labor union representing them) will accept only small increases, or even resign themselves to small decreases in the nominal wage in order to increase the employment rate. Corresponding to the center of the curve, there is a flat region where labor is resisting wage inflation decreases at the given expected price inflation. Finally, as soon as the unemployment rate is below its inflationary barrier, workers will exercise their increased bargaining power in requiring significantly more than proportional increases in wage inflation (as compared to price inflation)". As we are considering the real wage growth, we assume that the real wage growth responds more positively to the employment rate when the capacity utilization rate is higher.

$$\Omega_0(u) = \Omega_1 u \tag{15}$$

Where $\Omega_1 > 0$ is the sensitivity of Ω_0 to demand (nonlinear wage growth response mechanism).

The middle worker's real wage growth is given by:

$$\hat{W_M} = \Omega_2(\psi_M^{target} - \psi_M) + \sigma_2\hat{b} \tag{16}$$

Where $\Omega_2 > 0$. ψ_M^{target} is a function of the middle worker's productivity. Unlike less skilled workers, whose wage share target depends only on the economic cycle, middle workers' wage share target is a function of their productivity. The wage share target depends positively on the productivity b. And, σ_1, σ_2>0.

$$\psi_M^{target} = b \tag{17}$$

Note that:

$$\hat{L_M} = g - \hat{b} \tag{18}$$

$$\hat{L_W} = g - \hat{a} \tag{19}$$

Where g is the economy's growth rate $\hat{Y}$, given by equation 9 ($(1 - \psi_W(1 + \eta\xi))$ is the profit share):

$$g = \gamma_o + u[\gamma_1 + \gamma_2(1 - \psi_W(1 + \eta\xi))] \tag{20}$$

In this version, the model is built for the short run as we analyze the relationship between wage inequality and the economic cycle. We assume, therefore, that labor productivity and capital stock are given, constant: $\hat{a} = 0$, $\hat{b} = 0$, $\hat{k} = 0$. Furthermore, note that, under this assumption, the bottom workers' employment and capacity utilization rates have a direct relationship.

$$e_W = \frac{L_W}{N_W} = \frac{Y}{K}\frac{L_W}{Y}\frac{K}{N_W} = \frac{uk}{a} \tag{21}$$

Under these assumptions, a higher degree of capacity utilization implies a greater employment rate: we assume $k = a$, so that $e_W = u$.

Equilibrium

In the steady-state equilibrium, we assume both variables (the wage inequality $\eta\xi$ and the aggregate demand u) adjust simultaneously, as in Goodwin's original paper (Goodwin, 1967, which considers the employment rate and the income distribution). We have two equations to find the equilibrium (equations 10 and 12): $\hat{u} = 0$ and $\hat{\eta\xi} = 0$.

Since $\hat{u} = 0$, we have $S = I$ (see Equation 10), where S is the total savings function; and I is the investment. Both variables are normalized by the capital stock. The following equation gives the effective demand equilibrium:

$$u^* = \frac{\gamma_o}{\psi_W[s_W + \eta\xi(s_M - 1 + \gamma_2) - 1 + \gamma_2] + 1 - \gamma_1 - \gamma_2} \tag{22}$$

Also, $\hat{\eta\xi} = 0$ implies:

$$\eta\xi^* = \frac{\Omega_2 b - \Omega_1\lambda_1 u^2 + \Omega_1\psi_W u}{\Omega_2\psi_W} \tag{23}$$

The effect of the bottom workers' wage share on demand is given by:

$$\frac{\partial u^*}{\partial \psi_W} = \frac{-\gamma_o[s_W - 1 + \eta\xi(s_M - 1 + \gamma_2) + \gamma_2]}{\Delta^2} \tag{24}$$

Where $\gamma_o > 0$, and $\Delta > 0$ is the denominator of the equation 22. It is positive by the Keynesian stability condition.

Note that $(s_W - 1) < 0$ and $(s_M - 1) < 0$. Also, γ_o, η, ξ, γ_2 are > 0. The demand is wage-led if:

$$(s_W - 1) + \eta\xi(s_M - 1) > (1 + \eta\xi)\gamma_2 \tag{25}$$

The demand regime is wage-led if the differential of propensities to save between bottom workers and capitalists $(s_W - 1)$ is high; and if the differential of propensities to save between middle workers and capitalists $(s_M - 1)$ is also significant enough to offset the right-hand side of the equation. In this case, income redistributions in favor of wages positively affect consumption and offset the negative effect on investment (which depends positively on the profit share via γ_2). The profit-led case is the most probable if the investment function is susceptible to the profit rate (γ_2 high).

The effect of wage inequality on demand is given by:

$$\frac{\partial u^*}{\partial \eta\xi} = \frac{-\gamma_o\psi_W(s_M - 1 + \gamma_2)}{\Delta^2} \tag{26}$$

Note that $(s_M - 1) < 0$, $\gamma_o > 0$, $\psi_w > 0$ and $\gamma_2 > 0$. If $(s_M - 1) > \gamma_2$ (similar to the wage-led condition), the economy exhibits an inequality-led regime in which there is redistribution from the class with a more pronounced propensity to save - capitalists - to middle workers, whose propensity to consume is higher. This redistribution process positively impacts aggregate demand. If $(s_M - 1) < \gamma_2$ (this condition is similar to the profit-led condition). In this case, increasing wage inequality has a contractionary effect on aggregate demand.

The wage inequality measure's response to the degree of capacity utilization depends on the economic cycle:

$$\frac{\partial \eta\xi^*}{\partial u} = \frac{\Omega_1\psi_W - \Omega_1\lambda_1 2u}{\Omega_2\psi_W} \tag{27}$$

Note that if the economy has a high demand level (high u), the wage inequality level tends to respond negatively to a shock in the degree of capacity utilization. The bottom workers' bargaining power (λ_1) makes the derivative more negative. Conversely, if the demand and/or the bottom workers' bargaining power are low, the derivative in equation 27 is more likely to be positive. Finally, a higher ψ_W contributes to a positive derivative: as the real wage growth depends on the conflict between firms and workers (Kalecki, 1971), a higher bottom workers' share in income diminishes the difference between their target and the actual share in income, also decreasing their real wages' growth.

We can rewrite equation 22 isolating the wage inequality measure:

$$\eta\xi = \frac{\gamma_o}{u\psi_W(s_M - 1 + \gamma_2)} + \frac{[\psi_W(1 - \gamma_2 - s_W) - 1 + \gamma_1 + \gamma_2]}{\psi_W(s_M - 1 + \gamma_2)} \tag{28}$$

Under the Keynesian stability condition, we have local stability:

$$\frac{\partial \hat{u}}{\partial u} < 0 \tag{29}$$

We also have local stability for the wage inequality measure:

$$\frac{\partial \hat{\eta\xi}}{\partial \eta\xi} < 0 \tag{30}$$

The impact of the following derivative depends on the conditions described above, about Equation 27:

$$\frac{\partial \hat{\eta\xi}}{\partial u} = \Omega_1\psi_W - \Omega_1\lambda_1 2u \tag{31}$$

Also, the sign of the following derivative depends on the conditions explained in Equation 26:

$$\frac{\partial \hat{u}}{\partial \eta\xi} = -\mu\psi_W u[s_M - 1 + \gamma_2] \tag{32}$$

We can find the equilibrium using Equations 28 and 23. Note Equation 28 is a hyperbola, and it is increasing and concave if $(s_M - 1) > \gamma_2$ (inequality-led regime / similar to the wage-led condition). In this case, the derivative in Equation 32 is positive. On the other hand, Equation 28 is decreasing and convex if $(s_M - 1) < \gamma_2$ (similar to the profit-led condition)- the derivative in Equation 32 is negative. Equation 23 is a parabola.

Figure 1 represents the case in which Equation 32 is positive (inequality-led regime), and Equation 31 is negative: the equilibrium is cyclical and stable. This case is more likely to happen when: the economy is wage-led, the bottom workers' bargaining power is

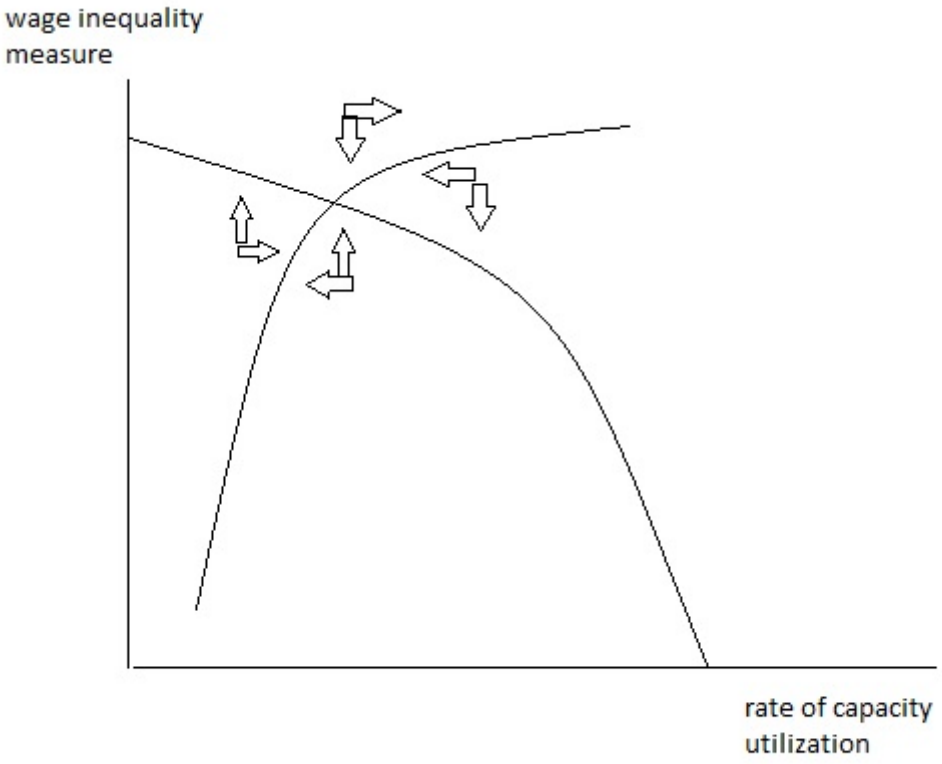

Figure 1 – Equilibrium - possibility 1

relevant, the economy has an elevated level of capacity utilization, and the bottom workers' share in income is low.

In this graph, increasing the wage inequality positively impacts the capacity utilization rate (inequality-led) because there is a redistribution from capitalists to the middle workers, whose propensity to consume is higher. As the derivative in Equation 31 is negative, the higher aggregate demand diminishes the wage inequality since bottom workers' employment rate depends positively on the aggregate demand. It increases bottom workers' employment, bargaining power in the labor market, and real wages - which diminishes the wage inequality measure. In this case, there is a cyclical pattern in the equilibrium: more wage inequality leads to a higher demand, which, in turn, depresses inequality. This stable pattern can be seen as a conciliation between the two worker classes.

However, this conciliation does not happen in Figure 2, which considers that both Equation 32 and Equation 31 are negative. This case is more probable when: the economy is profit-led; the bottom workers' bargaining power is elevated; the economy has a high level of capacity utilization; the bottom workers' share in income is low.

This case illustrates that a more significant wage inequality leads to a decrease in aggregate demand, which, in turn, boosts inequality. The economy is likely to have a low

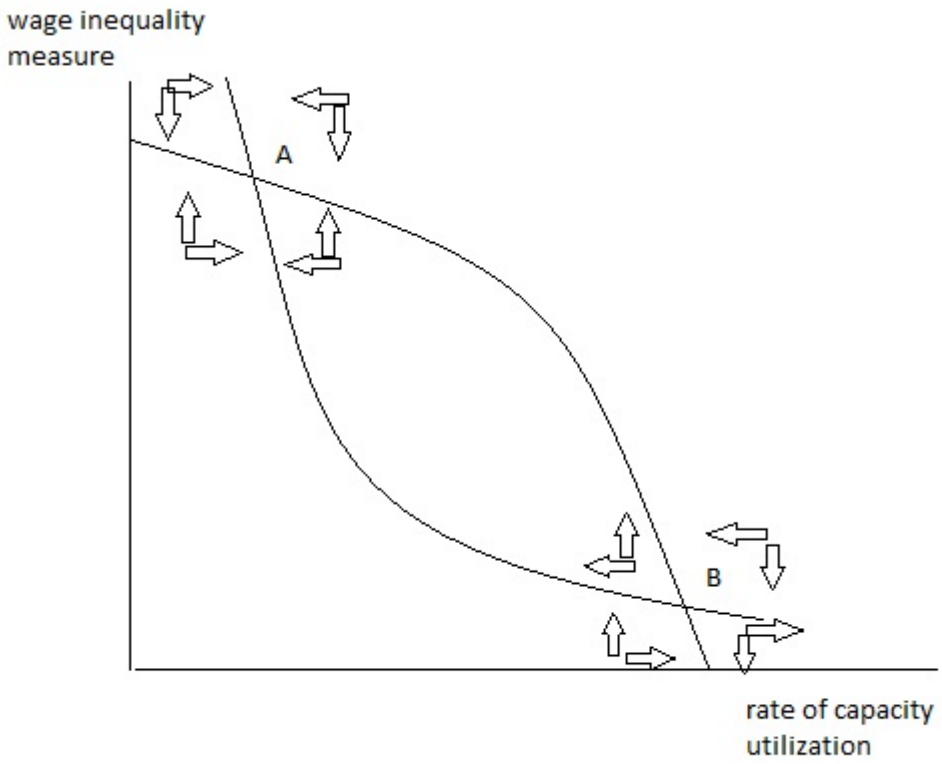

Figure 2 – Equilibrium - possibility 2

degree of capacity utilization combined with an elevated wage inequality (equilibrium A). Note that equilibrium A is stable, while equilibrium B has the possibility of instability. The economy may go to a point where the degree of capacity utilization is low or may move towards overheating.

Figure 2 makes the conflict between workers more evident: policies aimed to boost the economy and the labor market are necessary in order to pull the economy out of a stable equilibrium in which there is a slowdown in aggregate demand, combined with pronounced inequality. This case is consistent with the empirical literature: when aggregate demand depresses, inequality rises and negatively impacts bottom workers' employment and wages. The income / wage inequalities are persistent and tend to decrease very slowly during the recovery (Hoover et al., 2009; Heathcote et al., 2020), which shows the necessity of policies. On the other hand, demand management is also necessary because equilibrium B can be unstable.

Figure 3 shows the case in which both Equations (31 and 32) are positive: it is more probable when the economy is wage-led; the bottom workers' bargaining power is weak; their income share is elevated, and the economy has a low capacity utilization rate. At some point, when aggregate demand increases, there is a negative relationship between wage inequality and the degree of capacity utilization.

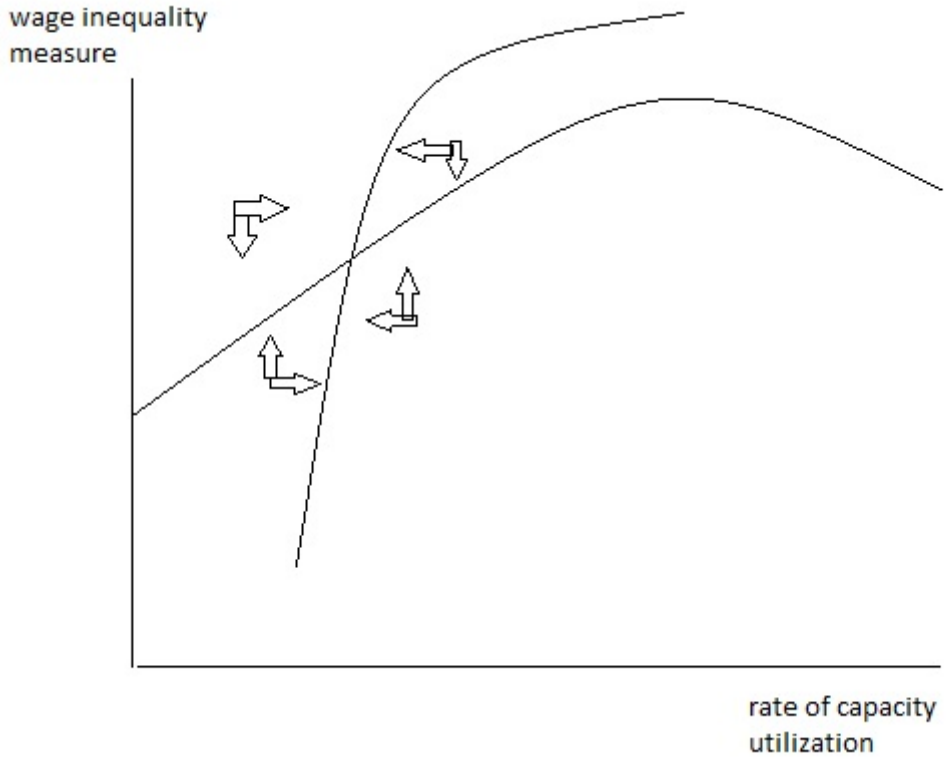

Figure 3 – Equilibrium - possibility 3

According to Figure 3, a more relevant wage inequality pushes aggregate demand, leading to greater wage inequality. It generates a stable dynamic process in which the demand is inequality-led, and the bottom workers cannot bargain for better wages.

Figure 4 illustrates the case in which Equation 32 is negative and Equation 31 is positive (equilibrium A). This situation is more likely to occur when the economy is profit-led, the bottom workers' bargaining power is weak, their income share is high enough, and the economy has a slowdown level of capacity utilization. There is a positive relationship between inequality and aggregate demand in this case. However, when the aggregate demand is higher, Equation 31 is negative (equilibrium B): the relationship between wage inequality and the degree of capacity utilization becomes negative.

Equilibrium A is stable and cyclical: a rise in wage inequality diminishes aggregate demand, leading to a decrease in wage inequality. Equilibrium B can be unstable. Similar to Figure 2, this case also illustrates the importance of policies to reduce wage inequality and boost aggregate demand.

Extension: changing the productivity

A possible extension is considering that productivity a and b are not constant:

$$\hat{b} = \alpha_2 \psi_M \tag{33}$$

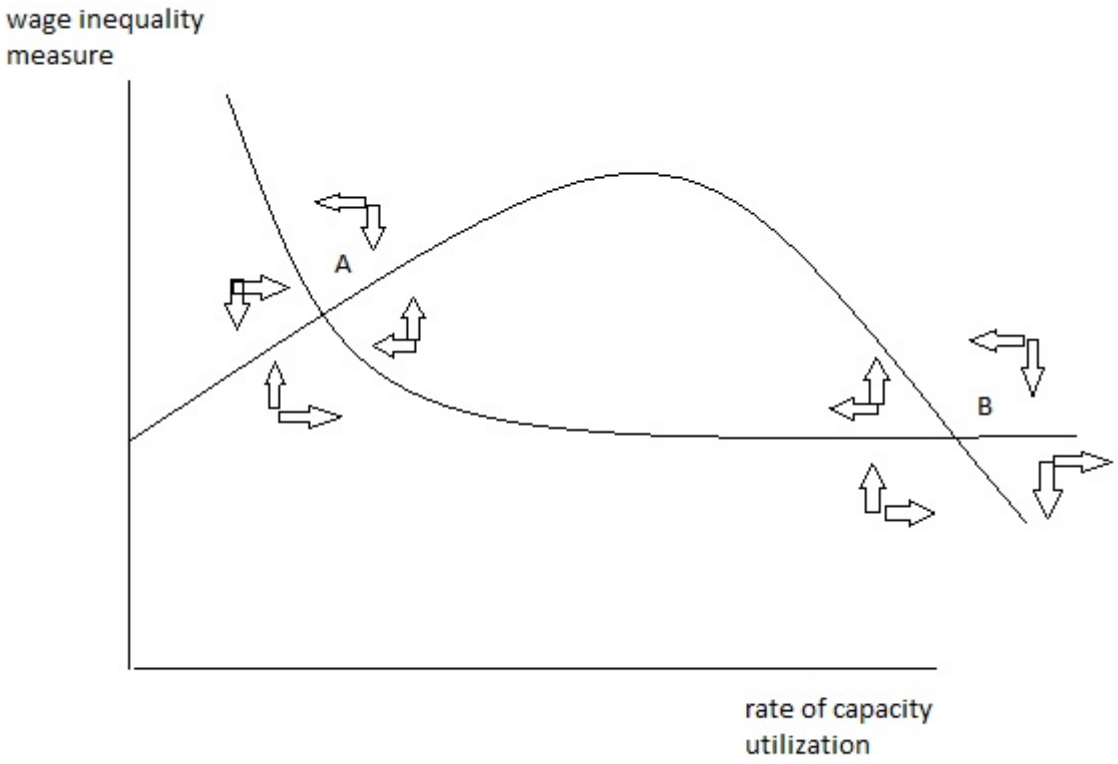

Figure 4 – Equilibrium - possibility 4

$$\hat{a} = \alpha_1 \psi_W \tag{34}$$

Where productivity vary according to the Webb effect (Lavoie, 2014)[5]. We consider this effect is more critical for the bottom workers ($\alpha_1 > \alpha_2$). The empirical literature has shown that routine and low-skill tasks are more accessible for robots to perform than non-routine, high-skill tasks (Arntz et al., 2017, Frey and Osborne, 2017, Dauth et al., 2017; Acemoglu and Restrepo, 2020; Lankisch et al., 2019). It means that low-skilled (bottom workers) are more adversely affected by technology, while high-skilled workers tend to specialize in tasks to which automation is complementary. In summary, since workers W are less skilled, an increase in their wage share can make it easier for them to be replaced by capital (which boosts their productivity), for example.

In this version, we can not consider that the employment rate varies in the same direction as the capacity utilization rate (see Equation 21) since a is not constant. Thus, we consider that the bargaining effect occurs via the employment growth rate instead of the employment rate:

$$\psi_W^{target} = \lambda_1 \hat{L_W} \tag{35}$$

[5] We do not include the Kaldor Veerdorn effect, since its interpretation is about the aggregate economy (and here we divide into two types of workers).

Where: $\hat{L_W} = g - \hat{a}$.

Where g is the economy's growth rate, given by the investment function. Due to algebraic reasons, we consider that the investment function depends only on the rate of capacity utilization (canonical function):

$$I = \gamma_o + \gamma_1 u \tag{36}$$

The equilibrium equations are given by:

$$u^* = \frac{\gamma_o}{\psi_W[s_W + \eta\xi(s_M - 1) - 1] + 1 - \gamma_1} \tag{37}$$

And:

$$\eta\xi^* = \frac{\Omega_2 b - \Omega_1\lambda_1\gamma_1 u^2 + u\Omega_1[-\gamma_o\lambda_1 + \alpha_1\lambda_1\psi_W + \psi_W] + \psi_W\alpha_1(1 - \sigma_1)}{\psi_W[\alpha_2(1 - \sigma_2) + \Omega_2]} \tag{38}$$

We can rewrite equation 37 isolating the wage inequality measure:

$$\eta\xi = \frac{\gamma_o}{u\psi_W(s_M - 1)} + \frac{[\psi_W(1 - s_W) - 1 + \gamma_1]}{\psi_W(s_M - 1)} \tag{39}$$

Equation 39 is an increasing and concave hyperbola (wage-led and inequality-led demand), while Equation 38 is a parabola.

Equations 29 and 30 (local stability) still hold. Also:

$$\frac{\partial\hat{\eta\xi}}{\partial u} = \Omega_1[-\gamma_o\lambda_1 + \alpha_1\psi_W\lambda_1 + \psi_W - 2u\gamma_1\lambda_1] \tag{40}$$

And (note $s_M - 1 < 0$):

$$\frac{\partial\hat{u}}{\partial\eta\xi} = -\mu\psi_W u[s_M - 1] > 0 \tag{41}$$

Equation 40 shows a positive relationship between wage inequality and the capacity utilization rate if the bottom workers' share in income and the Webb effect parameter α_1 are elevated enough. If the Webb effect is substantial, bottom workers' productivity increases when their income share rises, which leads to a decrease in their employment rate and bargaining power. This process generates more wage inequality.

Equation 40 is likely to be negative if the degree of capacity utilization, the autonomous investment γ_o and the investment function parameter γ_1 are significant enough (and if the Webb effect is low).

Figures 1 and 3 represent each case. The interpretation is the same as before. The only novelty in this version is that the Webb effect, as well as γ_o and γ_1, influence the relationship between wage inequality and the rate of capacity utilization.

4. Concluding remarks

There is substantial evidence in the empirical literature that the wage inequality in the left tail (middle-bottom) widens sharply during recessions while inequality between the top and the bottom of the wage distribution increases steadily (Heathcote et al., 2020; Guvenen et al. 2017; Bonhomme and Hospido, 2012; Alessandrini et al., 2016; Bowlus et al., 2021). The literature also finds that income inequality is countercyclical (Blank and Blinder, 1986; Morin, 2019; Geiger et al., 2020), since less skilled workers are more vulnerable to business cycle movements (Hoynes et al., 2012; Clark and Summers, 1981). Moreover, empirical evidence of the Goodwin cycle reported in the literature suggests the importance of worker's bargaining mechanisms when the economy is growing (Barbosa Filho and Taylor, 2006; Mendieta-Munhoz et al., 2020).

Based on the empirical evidence reported above, this paper intends to fill a gap in the theoretical Kaleckian literature since models have considered the wage inequality between the top and the bottom of the wage distribution. Using this approach, they neglect the effect of the cycle/aggregate demand on wage inequality and the relationship between workers from the middle and the bottom of the wage pyramid.

The model includes three classes in a Kaleckian-Goodwinian approach – capitalists and two types of workers (bottom and middle workers). Considering only the case in which wage inequality responds negatively to a shock in aggregate demand (figures 1 and 2), we analyzed two cases. When the demand is inequality-led, the equilibrium is cyclical and stable, with a conciliation between the two classes of workers. When the demand is not inequality-led, conflicts between workers become evident, and instabilities may appear. Also, in this last case, policies aimed at reducing wage inequality are crucial in order to avoid a stable equilibrium with low-capacity utilization levels and high wage inequality.

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